


# Strategic trade policy and non-linear subsidy : in the case of price competition

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## IDE DISCUSSION PAPER No. 287

### **Strategic Trade Policy and Non-Linear Subsidy -In The Case of Price Competition-**

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#### **Abstract**

In a strategic trade policy, it is assumed, in this paper, that a government changes its disbursement or levy method so that the reaction function of a home firm approaches infinitely close to that of a foreign firm. In the framework of the Bertrand-Nash equilibrium, Eaton and Grossman[1986] showed that an export tax is preferable to an export subsidy. In this paper, it is shown that an export subsidy is preferable to an export tax in some cases in the framework of the Bertrand-Nash equilibrium, considering the uncertainty in demand. Historically, many economists have mentioned a non-linear subsidy or tax. However, optimum solution to this has not yet been shown, and so the optimum solution is shown in this paper.

**Keywords:** strategic trade policy, non-linear subsidy, Bertrand-Nash equilibrium, Stackelberg equilibrium

**JEL classification:** F12, F13, L52, C72

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## I INTRODUCTION

Under a condition of international oligopoly, a country's trade profit can be increased by expanding its production volume. Additional rent for an exporting firm brought by expansion of production volume increases a country's trade profit. Individual governments thus tend to protect and foster domestic industries, with the intent of capturing and increasing rents. Then, in the case of price competition, a government subsidy works to decrease the social profit of the home country through the transfer of rent. In this case, a trade tax will increase the profit of the home country.

To clarify the economic effectiveness of strategic trade policy under such conditions, now we assume a case in which each firm competes in a Bertrand-type price framework, considering uncertainty in demand based on Klemperer and Meyer [1986].<sup>1</sup> Production by domestic and foreign firms is exported entirely to third countries, i.e., none of the firms' production is consumed in either country. We also assume that products are substitutable.

Initial work in this area was done by Brander and Spencer [1985]; their model has been extended by Eaton and Grossman [1986]. The basic idea behind a strategic trade policy in the case of price competition is as follows. First, we consider the case of free trade. In Figure 1, point E0 shows the Bertrand-Nash equilibrium, which is the intersection of reaction functions for the home and foreign firms. Point Et indicates the Stackelberg equilibrium on which a home firm can maximize its profit, existing on the iso-profit curve,  $\pi_t$ . If a home firm is a Stackelberg leader, it is possible to reach point Et. However, a foreign firm is in the same situation. As the two firms confront the same conditions, it is impossible to identify a Stackelberg leader.

Despite this constraint, if the marginal costs of the home firm increase, it will increase its price irrespective of the price level of the foreign firm. Government can reduce the firm's

incentive to produce by levying tax. If the government chooses an appropriate tax level, the home firm can now attain the Stackelberg equilibrium.<sup>ii</sup> In Figure 1, the reaction function of the home firm shifts down and to the right, showing the influence of the government tax. (This shows the case of linear tax.)

The home country's trade profits can be obtained as export profits of the home firm minus the government tax. The iso-profit curve of the home firm under free trade at point E0, the Stackelberg equilibrium, is equivalent to the trade profits of the home country at point Et. Under the above scenario, a government can maximize the home country's trade profits by levying tax.

Eaton and Grossman [1986] showed that an export subsidy is preferable in Cournot type competition if the conjectural variation of the home firm is larger than the consistent conjecture. They also showed that the export tax is preferable in Bertrand competition if the conjectural variation of the home firm is smaller than the consistent conjecture.

Klemperer and Meyer [1986 and 1989] introduced the uncertainty into demand. They showed that firms choose quantity (price) to control in competition if the cost curve is convex or rather concave (concave or rather convex). Therefore, the market conduct should be Cournot-type and Bertrand-type under the assumption of uncertainty in demand.

Qiu [1995] studied the non-linear subsidy using this classification.<sup>iii</sup> He assumed that the cost curve is a quadratic form of production volume and the constant term is zero. Then, the subsidy is assumed to be a quadratic function of production volume. Firstly, if the slope of the marginal cost curve is negative, it should be changed to zero by the subsidy. Secondly, subsidization is conducted to attain an optimum point. In the latter case, the subsidy should be the same amount for any production unit.

In this paper, it is assumed that the cost curve is a quadratic form of production volume and the slope of the marginal cost curve is negative. Then, it is also assumed that the absolute value of the slope of the marginal cost curve is rather large and the market conduct is

Bertrand type, based on the classification of Klemperer and Meyer [1986].

It is shown that we can find a case in which an export subsidy is preferable in Bertrand-type competition in this paper. When a government subsidizes a home firm, the price of it will increase. Then, compared with the case of Eaton and Grossman [1986], it becomes possible for a government to increase the home country's trade profit.

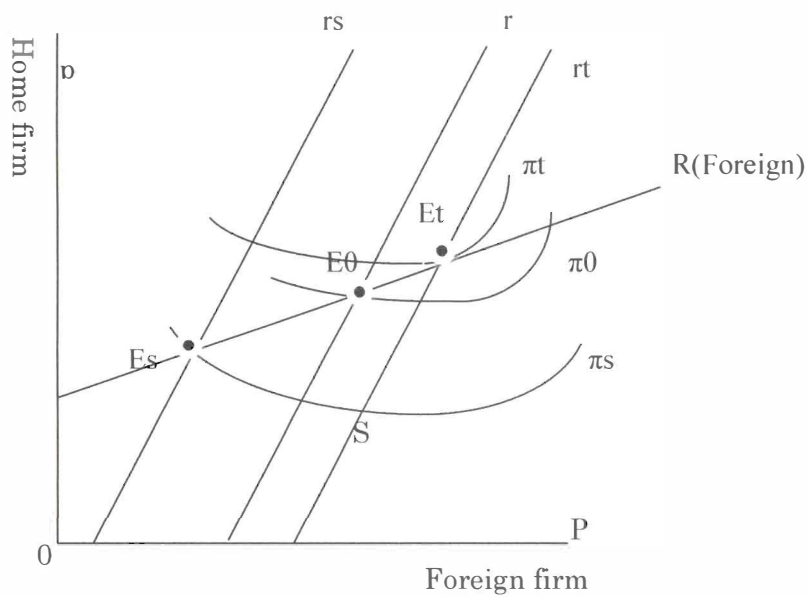


Figure 1

## II TAX AND CHANGES IN THE REACTION FUNCTION

Here, we assume the demand function of the home firm as follows.

$$x = -ap + bP + c \quad (a > 0, b > 0, c > 0)$$

p: price of home firm

P: price of foreign firm

The cost function of the home firm is assumed as follows.

$$c = d \frac{x^2}{2} + ex + f$$

Therefore, the profit function of the home firm is as follows.

$$\Pi(P, p) = p \cdot x(p, P) - c(x) + s \cdot x(p, P)$$

S: subsidy or tax for the home firm

The reaction function of home firm is obtained by maximization as follows.

$$(-ap + bP + c) + (-a)p - (dx + e)(-a) + s(-a) = 0$$

Therefore, the reaction function of the home firm is as follows.

$$p = \frac{b(1+ad)}{a(2+ad)}P + \frac{c+acd+ae}{a(2+ad)} - \frac{s}{(2+ad)} \quad (1)$$

Now, we assume that the reaction function of the foreign firm is as follows.

$$P = Ap + B \quad (2)$$

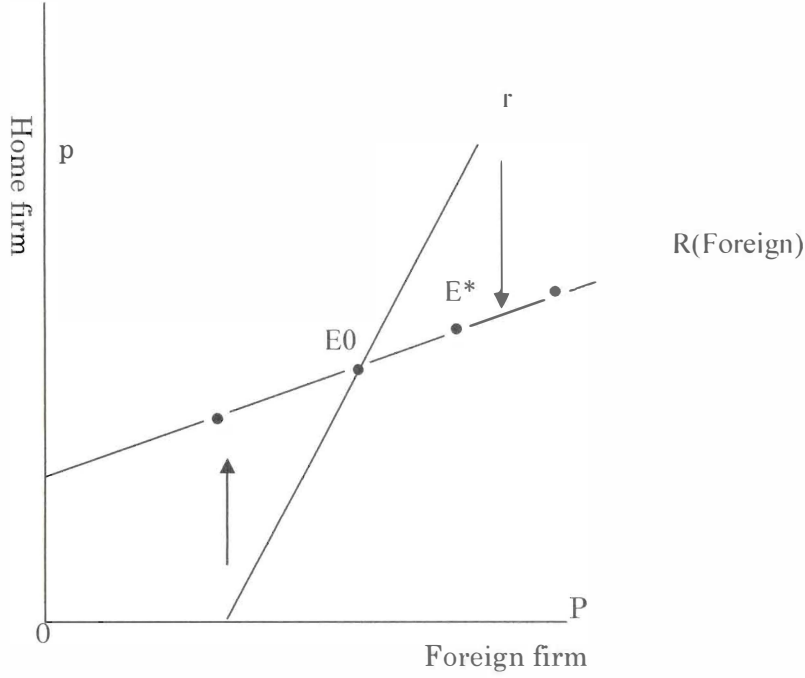


Figure 2

Then, the subsidy is now assumed to be zero. By solving equation (1) and (2), we obtain the equilibrium point  $E_0$  under free trade as follows.

$$p = \left\{ \frac{1}{a(2+ad)} \right\} \cdot \left[ Ab(1+ad) \left( \frac{c+acd+ae+ac+a^2cd+a^2e}{a(2+ad)-Ab(1+ad)} \right) + c+acd+ae \right] \quad (3)$$

$$P = \frac{A(c+acd+ae)}{a(2+ad)-Ab(1+ad)} \quad (4)$$

If the reaction function of the home firm approaches gradually and infinitely close to that of the foreign firm while keeping its distance constant, the new equilibrium point  $E^*$  can be obtained. As shown in the appendix, if a segment approaches infinitely close to another segment, the intersection approaches to a certain point.



In this paper, it is assumed that the reaction function of the foreign firm does not change in response to changes in the home firm's reaction function; instead, it remains in the same position.

### III THE HOME FIRM'S REACTION FUNCTION IS SHIFTED BY TAX

If the home government levies a constant tax  $t$  per unit of production, the reaction function of the home firm can be described as follows.

$$p = \frac{b(1+ad)}{a(2+ad)}P + \frac{c+acd+ae}{a(2+ad)}a + \frac{t}{(2+ad)} \quad (5)$$

We assume that the reaction function of the foreign firm is as follows.

$$P=Ap+B \quad (6)$$

Intersection of these reaction functions is as follows by the solutions of (5) and (6).

$$p = \left\{ \frac{1}{a(2+ad)} \right\} \cdot \left[ Ab(1+ad) \left( \frac{c+acd+ae+ac+a^2cd+a^2e}{a(2+ad)-Ab(1+ad)} \right) + c+acd+ae+at* \right] \quad (7)$$

$$P = \frac{A(c+acd+ae+at*)}{a(2+ad)-Ab(1+ad)} \quad (8)$$

Because the demand function of the home firm is  $x = -ap + bP + c$ , production of the home firm is as follows.

$$x_t = -a \times \left\{ \frac{1}{a(2+ad)} \right\} \cdot \left[ Ab(1+ad) \left( \frac{c+acd+ae+ac+a^2cd+a^2e}{a(2+ad)-Ab(1+ad)} \right) + c+acd+ae+at* \right] + b \frac{A(c+acd+ae+at*)}{a(2+ad)-Ab(1+ad)} + c \quad (9)$$

Therefore, total tax for the home firm becomes as follows.

$$T=t^* \times \left( -a \times \left\{ \frac{1}{a(2+ad)} \right\} \cdot \left[ Ab(1+ad) \left( \frac{c+acd+ae+ac+a^2cd+a^2e}{a(2+ad)-Ab(1+ad)} \right) + c + acd + ae + at^* \right] \right. \\ \left. + b \frac{A(c+acd+ae+at^*)}{a(2+ad)-Ab(1+ad)} + c \right) \quad (10)$$

Because the optimum tax is already obtained by Eaton and Grossman [1986], this value is supposed as given ( $t^*$ ).

### III-2 THE HOME FIRM'S REACTION FUNCTION APPROACHES INFINITELY CLOSE TO THE FOREIGN FIRM'S REACTION FUNCTION

We assume that the home government levies the tax to manipulate not only the constant coefficient  $d$  in the marginal cost of the home firm,  $dx+e$ , but also the coefficient  $e$ . In this case, the home firm's reaction function can be made to approach infinitely close to the foreign firm's reaction function. Equations (1)' and (2)' are equalized at the limit. When we assume the coefficient of  $p$  and constant coefficient are identical in equations (1)' and (2)'', we obtain equations (11) and (12).

$$p = \frac{b(1+ad)}{a(2+ad)}P + \frac{c+acd+ae}{a(2+ad)} \quad (1)'$$

Now, we assume that the reaction function of foreign firm is as follows.

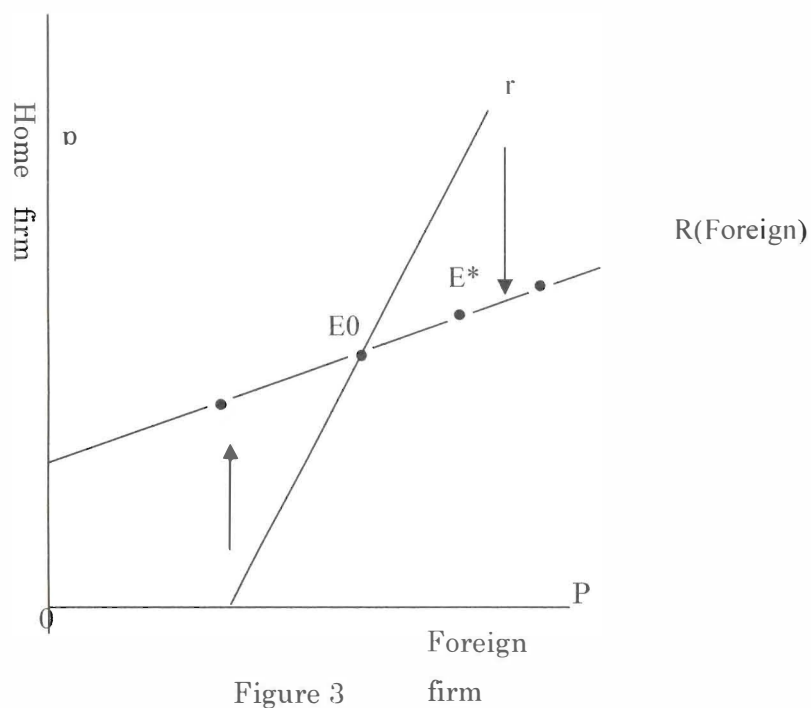
$$P=A\rho+B \quad (2)'$$

$$p = \frac{P}{A} - \frac{B}{A} \quad (2)''$$

It is possible to obtain the values of  $d$  and  $e$  (marginal cost  $dx+e$ ) at the limit by solving these two equations.<sup>iv</sup>

$$d^* = \frac{(2a-bA)}{a(Ab-a)} \frac{-1}{Aa} \left\{ Ac + 2aB + \frac{(2a-bA)(Ac + Ba^2)}{a(Ab-a)} \right\} \quad (11)$$

$$e^* = \left( \frac{-1}{Aa} \right) \left\{ Ac + 2aB + \frac{(2a-bA)(Ac + Ba^2)}{a(Ab-a)} \right\} \quad (12)$$



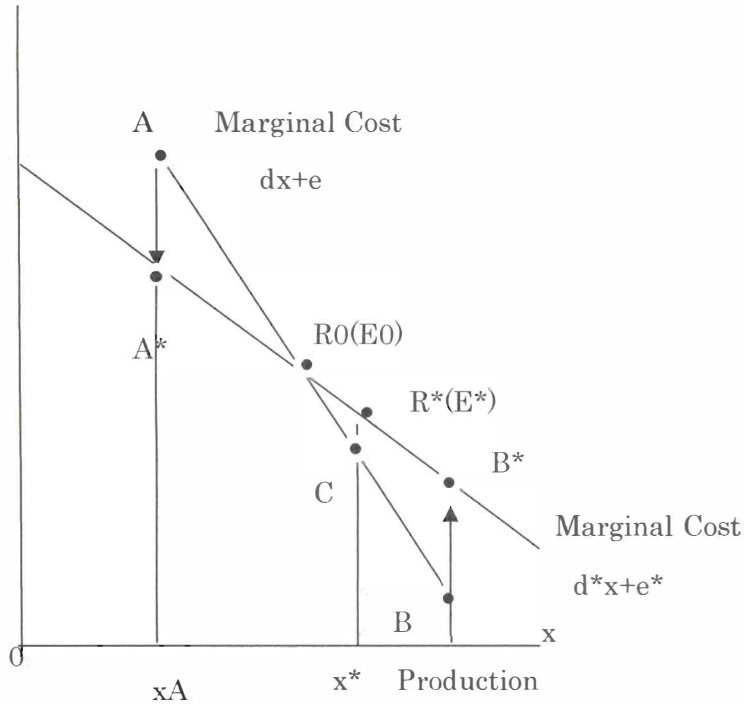


Figure 4

The amount of the subsidy in this case can be obtained as follows.

$$\int_{x_A}^{x^*} \left\{ (d - d^*)x + (e - e^*) \right\} dx \quad (13)$$

As the home reaction function approaches the foreign reaction function, the marginal cost curve,  $dx+e$ , approaches the marginal cost curve,  $d^*x+e^*$ . As explained in the appendix, the length of segment  $AB$  should be equal to the length of segment  $A^*B^*$ . Therefore, the triangle  $AA^*R_0$  refers to the subsidy, and the triangle  $R_0CR^*$  refers to the tax. The Stackelberg equilibrium obtained by Eaton and Grossman [1986] is the point  $R^*(E^*)$ . According to the appendix, when the point  $R^*(E^*)$  is given, the segment is determined. In this case, the Stackelberg equilibrium obtained by Eaton and Grossman [1986] is obtained by subsidy not by tax, because the area of triangle  $AA^*R_0$  is larger than the triangle  $R_0CR^*$ . It is possible to say that subsidy is preferable under the price competition in this case.

#### IV SUMMARY

Eaton and Grossman [1986] showed that an export subsidy is preferable in Cournot-type competition and that the export tax is preferable in Bertrand competition.

In this paper, it has been shown that we can find a case in which an export subsidy is preferable in Bertrand-type competition, considering uncertainty in demand based on Klemperer and Meyer [1986]. When a government pays a subsidy to the home firm, the prices of the two firms increase and productions decrease. Then, the home firm can attain the Stackelberg equilibrium.

Historically, many economists have mentioned non-linear subsidies. However, the optimum solution for it had not yet been shown. The optimum solution was shown in this paper.

## APPENDIX

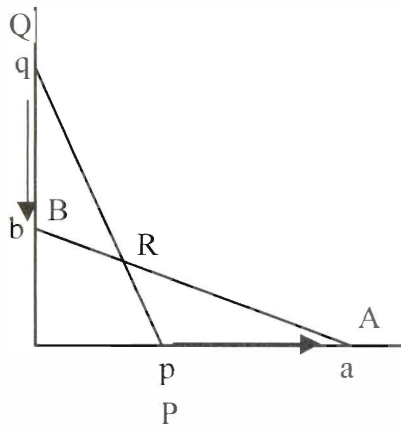


Figure5

In Figure 5, it is assumed that segment PQ approaches segment AB. Then, the length of PQ should be held equal to the length of segment AB when segment PQ comes sufficiently close.

$$p^2 = a^2 + b^2 - q^2$$

Segment PQ satisfies  $\frac{x}{p} + \frac{y}{q} = 1$  Segment AB satisfies  $\frac{x}{a} + \frac{y}{b} = 1$ .

The intersection of two segments is as follows.

$$x = \frac{ap(b - q)}{bp - aq}, y = \frac{bq(a - p)}{aq - bp}$$

Here, the next relationship is used.

$$p^2 = a^2 + b^2 - q^2$$

As a result, the next equation should hold.

$$b^2 p^2 - a^2 q^2 = b^2(a^2 + b^2 - q^2) - a^2 q^2 = (a^2 + b^2)(b^2 - q^2)$$

If the numerator and denominator of the x component of intersection are multiplied by (bp+aq), the following relationship is obtained.

$$x = \frac{ap(b-q)(bp+aq)}{b^2 p^2 - a^2 q^2} = \frac{ap(b-q)(bp+aq)}{(a^2 + b^2)(b^2 - q^2)} = \frac{ap(bp+aq)}{(a^2 + b^2)(b+q)}$$

When point P approaches point A and point Q approaches point B,

$p \rightarrow a, q \rightarrow b$ , the x component of intersection approaches

$$\frac{a^2(ba+ab)}{(a^2+b^2)(b+b)} = \frac{a^3}{a^2+b^2}$$

In a similar manner, the limit of the y component of intersection can be obtained. As a result, the limit of intersection should be as follows.

$$\left( \frac{a^3}{a^2+b^2}, \frac{b^3}{a^2+b^2} \right)$$

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## NOTES

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<sup>i</sup> According to Klemperer and Meyer [1986], if a cost function is convex or rather concave, quantitative competition is chosen. If a cost function is concave or rather convex, price competition is chosen. This result came from the variation of uncertainty,  $\theta$ , which is an intercept of the y-axis of the demand function.

<sup>ii</sup> In this case, prices of both firms increase and production volumes decrease. However, the home firm can increase its profit.

<sup>iii</sup> Qiu [95] studied the non-linear subsidy. However, the idea of equilibrium in this paper is different from his idea of equilibrium.

<sup>iv</sup> Despite the length of the segments, all segments approach segments located on the same line.